Simple analyses of ship and large whale collisions: Does speed kill?

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Abstract

Large whale deaths and serious injuries that result from ship strikes are of increasing concern among those engaged in whale conservation worldwide, and ship strikes pose a considerable threat to recovery of the North Atlantic right whale. Proposed ship strike reduction strategies have included reducing ship speeds as an approach to reducing ship strikes. We analyzed recent records of ship and whale collisions in cases that vessel speed was reported (n=64). We tested speed as a predictor of the probability of whale death or serious injury in a logistic regression model. We also compared the distribution of vessel speeds from ship and whale collisions with the distribution of speeds from large vessels that transit two important North Atlantic right whale habitat areas where ships are required to report upon entry. One area was near Cape Cod, Massachusetts, USA, and the other encompassed part of the right whale calving area along Southeastern USA. We found strong evidence that the probability of death or serious injury increases rapidly with increasing ship speed. A predicted 50% [0.26-0.71 for 95% C.L.] chance of death or serious injury occurred at 10.5 knots, but increased to 90% at 17 knots. There was little coincidence between the distribution of speeds of ships striking whales and speeds reported by ships entering the Mandatory Ship Reporting (MSR) areas near Cape Cod and the southeastern US calving area. The distribution of speed for ships striking whales was relatively linear and was influenced by both relatively slow and very fast vessels that struck whales. Speeds of vessels entering the MSR areas were heavily concentrated (90% of reported speeds) between 10 and 20 knots with a median of 14.5 knots. We conclude that managing vessel speed could be an important consideration in reducing large whale deaths from ship strikes.

Introduction

Large whale deaths and serious injuries that result from ship strikes are of increasing concern among those engaged in whale conservation worldwide (Kruas et al. 2005). For example, the United States and Canadian governments have each been engaged in actual or planned ship rerouting regulations developed primarily as protective measures to reduce ship strikes to the highly endangered North Atlantic right whale (*Eubalaena glacialis)*. Proposed ship strike reduction strategies have included reducing ship speeds as an approach to reducing ship strikes. (see **http://www.nmfs.noaa.gov/pr/shipstrike**). Various outcomes have been described from the result of ships and whales colliding (Laist et al. 2001) including at least one case in which the whale won (Philbrick 2000). An association of increasing severity of injury to whales with increased vessel speed has been suggested without benefit of examining the statistical level of evidence relating vessel speed to fates of whales involved in these collisions. Here, we provide a simple analysis of whale and ship collision data relative to whale fates. We also examine the speeds of vessels entering important right whale habitat areas along the United States Atlantic coast..

Methods

We analyzed recent records of ship and whale collisions in cases that vessel speed was reported (n=64), including 53 cases for which the fate of the whale was described in sufficient detail to classify into one of 2 classes: not severe or severe, the latter including death and injuries likely to result in death (Jensen and Silber 2004). We tested speed as a predictor of the probability of whale death or serious injury in a logistic regression model. (Hosmer and Lemeshow 1989). We also compared the empirical cumulative distributions of vessel speeds from ship and whale collisions with the distribution of speeds from large vessels that transit two important North Atlantic right whale habitat areas where ships are required to report upon entry (Ward-Geiger et al. 2005). One area was near Cape Cod, Massachusetts, USA, and the other encompassed part of the right whale calving area along Southeastern USA.

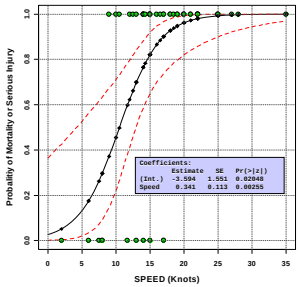

Figure 1. Fitted logistic regression showing the relationship between serious injury and vessel speed. (Green dots are observed, black diamonds are predicted and red-dashed lines are the 95% CI about the individual predicted values.

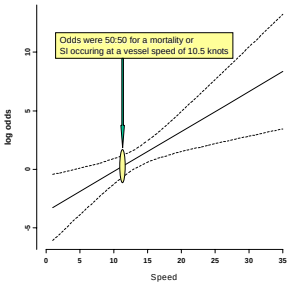

Figure 2. Predicted log odds and CI resulting from a logistic regression that fit Prob(serious injury) to 53 pairs of whale fate and vessel speed data.

Results

We found strong evidence (P=0.0025) that the probability of death or serious injury increases rapidly with increasing ship speed (Figure 1). The predicted probability of a serious injury or mortality increased from 45% to 75% as vessel speed increased from 10 to 14 knots and exceeded 90% at 17 knots. Predicted probabilities and odds had rather large confidence bands owing to the small sample size (n=53; Figures 1 & 2).

Modest disparity existed between the distribution of vessels speeds reported by entrants in to the Northeast MSR and Southeast MSR areas (Figures 3 & 4). In the Northeast, 25% of entrants were cruising at 13.0 knots or below and the next 25% were between 13 and 14 knots! In the southeastern MSR, vessels speeds were not as concentrated about a higher median speed of 15.7 knots. The distribution of speeds of vessels colliding with whales was far from coincident with speed distributions from either MSR, owing to some collisions occurring at speeds exceeding 30 knots (Figure 4).

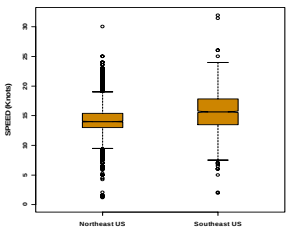

Figure 3. Box plots comparing speeds of vessels entering 2 Mandatory Ship Reporting areas established for North Atlantic right whale conservation off the Atlantic US coast. Orange boxes represent the middle quartiles and whiskers are at 2 standard deviations

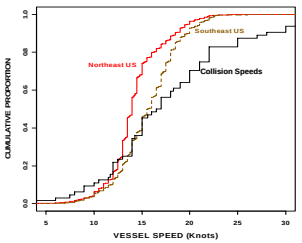

Figure 4. Empirical distributions of speeds of vessels colliding with whales and speeds of vessels entering 2 Mandatory Ship Reporting areas established for North Atlantic right whale conservation off the Atlantic US coast.

Discussion

Our simple analyses demonstrated the importance of considering vessel speed when attempting to manage impacts of vessel traffic on whales. We found clear evidence of a sharp rise in mortality and serious injury rate with increasing vessel speed. We note that the data we examined contained no information about the probability of a ship strike occurring, and this aspect of risk needs further attention.

We believe that the lack of coincidence between collision speeds and MSR entrant speeds is a result several factors. First, the collision data set is relatively small and therefore considerable uncertainty accompanies the empirical distribution function that we provided. Second, we believe that there is a strong bias in reporting rates of ship-whale collisions among vessel types with fast ships from the United States military having much higher reporting rates than other vessels. We note that the collision data are from throughout the world whereas the MSR data represent only a small fraction of shipping traffic through areas occupied by whales.

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